Can variability in subsoil constraints be spatially managed in the high rainfall zone of SE Australia?

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Abstract

Cropping soils in the high rainfall zone (HRZ) of SE Australia are mostly duplex and poorly drained due to heavy clay subsoils. These soils can limit root growth, reduce crop water use efficiency and lead to severe waterlogging. Four representative paddocks across the HRZ (Marrar in NSW, Yarrawonga and Lake Bolac in Victoria and Frances in SA) were remotely surveyed in 2005 during late summer or early autumn to quantify the spatial extent of these subsoil constraints. Transects of soil cores to ground-truth the remotely sensed data were analysed for physical and chemical properties. Apparent conductivity (EC_a) measured with the EM38 was either positively or negatively correlated with $EC_{1:5}$, clay content, exchangeable sodium percentage (ESP), field capacity (FC) and lower limit (wilting point) depending on location. In both the presence and absence of root-zone salinity levels deleterious to crop growth, EC_a was also well correlated with yield of wheat, triticale and canola derived from yield maps. Zonal amelioration strategies such as site specific deep tillage and surface drainage works within the paddock can be considered for several soil types on the basis of variation in soil properties and topography.

Key Words

High rainfall zone, subsoil constraint, spatial variability, conductivity, yield maps

Introduction

Cropping in the high rainfall zone (HRZ) of SE Australia has increased due to a run of dry seasons in traditional cropping areas and more favourable returns compared to wool grazing enterprises. Soils in the HRZ are mostly duplex and are poorly drained due to heavy clay subsoils. These subsoils are often sodic, which can cause restricted water flow, reduced nutrient availability and mechanical impedance to growth of roots, reduce crop water use efficiency and lead to severe waterlogging. Variable topography in the HRZ also has the potential to interact spatially with subsoils and affect redistribution of water. In this study we surveyed paddocks at four locations across the HRZ in SE Australia to assess the variability in subsoil conditions and the implications of these on yield and possible amelioration strategies. A key assumption behind the rationale of the site investigations was that subsoil conditions impacted both directly on root growth and indirectly via waterlogging on the water use and final crop yield of the crop.

Methods

Paddock surveys

Four representative paddocks across the HRZ were surveyed in 2005 during late summer or early autumn when water from summer rainfall was apparent in subsoil clay (Marra in NSW, Yarrawonga and Lake Bolac in Victoria and Frances in SA). Sensors used to assess subsoil physio-chemical variability were dipolar EM38 (vertical 1.5?m and horizontal 0.75?m depths), EM31 (3?m depth averaged) and gamma radiometer (Exploranium™ GR 320) mounted on a quad bike. Real-time spatial position was logged on a differential geographic position system (Navcom™ DGPS) (Rampant, 2003). EM sensors measured soil texture and salinity at a range of depths, while the gamma radiometer measured mineral elements in near-surface clay.

Soil sampling transects

Transects for soil sampling were selected on the basis of conductivity readings, slope and location. Intact cores were taken at 30 m intervals down-slope (Figure 1). Selected increments (0–10, 20–30, 45–55 and 100–110?cm depths) representing soil horizons were air-dried at 40?^{o}C and ground to pass through a 2?mm screen then analysed. Sub samples were ground to pass through a 1?mm sieve and analysed with mid-infra-red (MIR) spectroscopy.

Data preparation and analysis

Apparent electrical conductivity (EC_a), yield and gamma spectra were interpolated using the inverse distance weighting method (Arcview 3.3a™ and Spatial Analyst 1.1™). Values for yield, salinity and potassium (K) content were taken from raster cells corresponding with the cores along transects and correlations derived using GENSTAT v8.0 (Payne et al. 2005).

Results

For brevity, data for selected locations is presented. Soil water content, salinity and clay content were directly related to the EC_a reading (Figure 1). Soil water content in the topsoil ranged from 5-32 % (v/v) (0-10 cm) and 20-52% (20-50 cm) in the subsoil at the time of the survey after summer rainfall. However, soil water content in the southern paddock at Yarrawonga was reduced by actively growing lucerne (Figure 1).

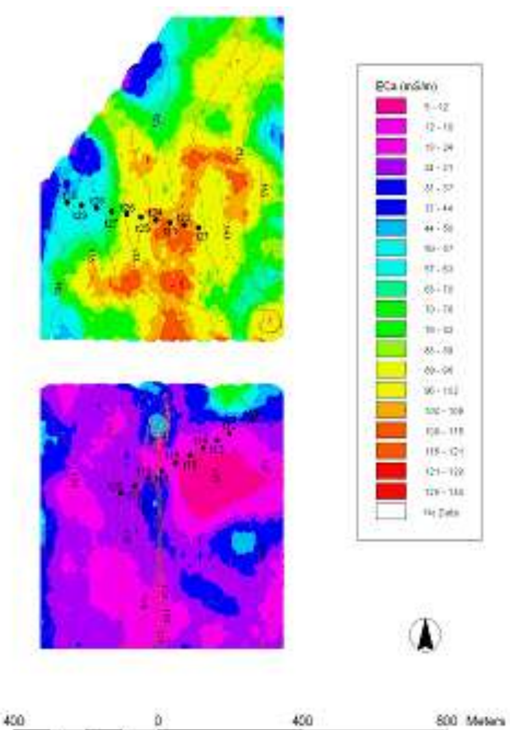

Figure 1. Maps of EC_a at Yarrawonga for Triticale (northern paddock) and canola (southern paddock) overlain with elevation contours and transects for cores.

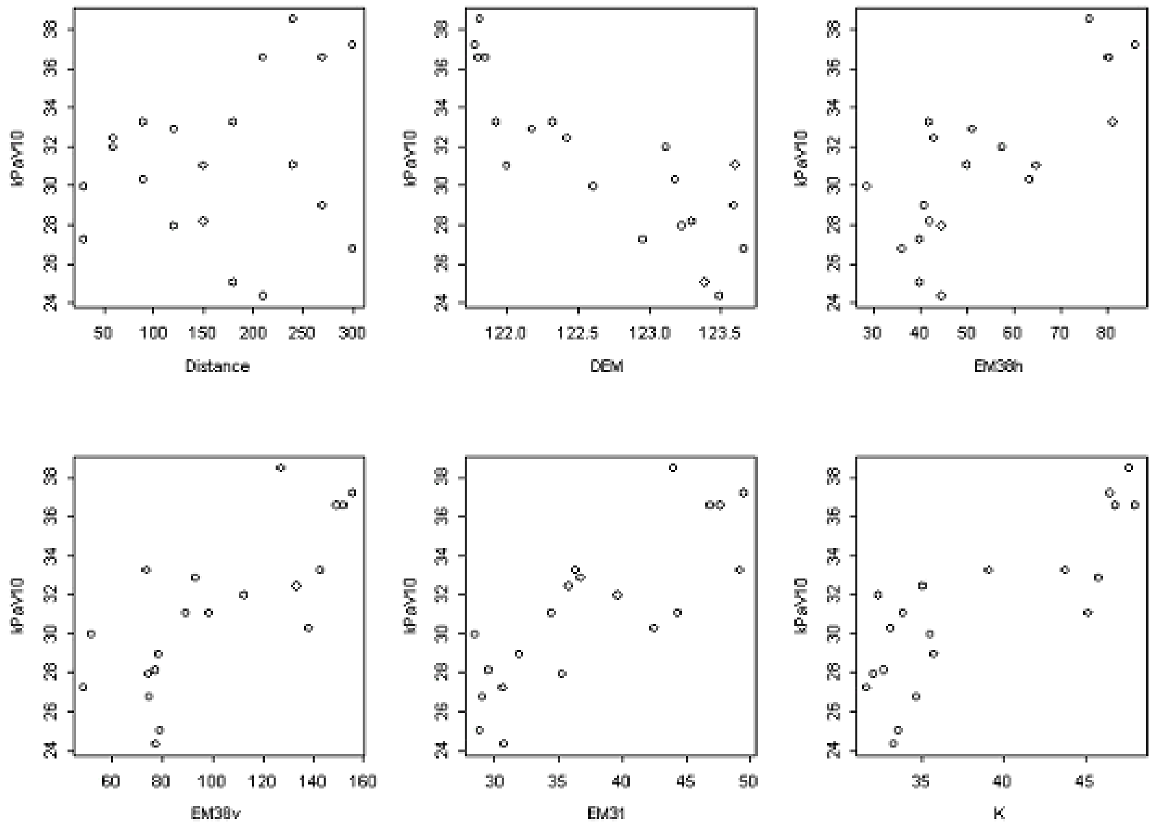

Figure 2: Scatter Plots of 10kPa V% versus EM38(v and h), elevation, ESP, survey data at Frances

Table 1. Correlation (r) between Yarrawonga survey data and selected analyses (cation exchange capacity (CEC), clay (%), exchangeable sodium percentage (ESP), lower limit (15 bar V%), field capacity (10 kPa V%) and organic carbon percentage (OC)).

Analyses		Transect	Elevation	EM38h	EM38v	EM31	K
Wet chemistry	EC	0.679	-0.456	0.872	0.868	0.879	0.264
	$pHCaCl_2$	0.582	-0.212	0.742	0.754	0.771	-0.153
Mid infra red (MIR analyses	CEC	0.764	-0.515	0.627	0.659	0.656	0.057
	Clay	0.7	-0.481	0.492	0.53	0.523	0.025
	ESP	0.556	-0.222	0.736	0.728	0.742	-0.009
	15bar V%	-0.776	0.491	-0.428	-0.514	-0.507	0.005

10kPa V%	-0.736	0.218	-0.565	-0.626	-0.633	0.168
OC	0.356	-0.129	0.501	0.523	0.523	-0.075

Field capacity (10kPa V%) at Frances showed a good relationship with the survey data (Figure 2). At Yarrawonga a good positive correlation between grain yield and EM38h shown for triticale (northern paddock; Figure 1) contrasted with a negative correlation for canola (southern paddock; Figure 1), which may have been influenced by the reduced moisture content from the previous lucerne. Interestingly, there was a positive correlation between grain yield and $EC_{1:5}$ for triticale in 2003, but little correlation of radiometric potassium (K) with yield of wheat in 2004.

Conclusion

Correlation between position in transect, elevation, EM38h and EM38v readings, showed reasonable ability of the survey data to predict crop yield given the semi-quantitative approach of the smoothing method and MIR data. The correlation between yield and distribution of soil properties suggests that a useful variation exists for identifying and exploiting spatial management of subsoil constraints in the HRZ.

Acknowledgements

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References

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